Effectiveness of Elemental S Fertilizers on Canola After Four Annual Applications

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Abstract

Plants feed on sulphate-S, but now elemental S fertilizers (which cost less per unit of S than the sulphate-S fertilizers) are available for commercial use. The effectiveness of elemental S fertilizers depends on how quickly the S is oxidized in soil for effective plant uptake. A 4-year field experiment was initiated in 1999 on S-deficient soils at two sites in northeastern Saskatchewan to determine the relative effectiveness of elemental S (ES-90 and ES-95) and sulphate-S (Agrium Plus containing both elemental S and sulphate-S, and ammonium sulphate) fertilizers on yield of canola seed. The S fertilizers were applied at 10 to 20 kg S ha^{-1} rates in the previous fall or in spring at sowing. At both sites, canola showed S deficiency and seed yields increased with the sulphate-S fertilizer in 1999, 2000, 2001 and 2002. In 1999, there was no significant increase in seed yield from the elemental S fertilizers, though fall application tended to give slightly greater seed yield than the spring application at one site. In 2000, 2001 and 2002, elemental S fertilizers usually corrected S deficiency on canola and increased seed yields significantly over the zero-S control, but yields were less than the sulphate-S fertilizer in most cases in 2000 and in many cases in 2001 and 2002, especially when the S fertilizers were applied in spring. Fall-applied elemental S usually had greater seed yield than the spring-applied elemental S in 2000, 2001 and 2002, and in some cases seed yields tended to be equal to sulphate-S fertilizer. Fall-applied ammonium sulphate produced (or tended to produce) lower seed yield than spring-applied ammonium sulphate in some cases. In summary, the results suggest that the elemental S fertilizers were not as effective as the sulphate-S fertilizer in increasing canola seed yields on S-deficient soils after four annual applications, particularly when the S fertilizers were applied in spring at seeding.

Introduction

In the Prairie Provinces, there are about 3.5 million ha of agricultural land under canola production, of which 1.6 million ha in Saskatchewan. Canola is the major cash crop in the Parkland zone and it has high requirements for S (Grant and Bailey 1993). As S is immobile in plants, deficiency of S can occur at any growth stage, which can cause considerable reductions in seed yield. In order to prevent any seed yield loss due to S deficiency, a constant supply of available S to canola plants is thus needed throughout the growing season. On soils marginally deficient in S, the application of higher rates fertilizer N can result in faster depletion of S from soil, and this will increase the instances and severity of S deficiency on canola during peak growing periods.

Plants feed only on SO_4-S. Traditionally, S supplied in fertilizers was usually present in the sulphate form, which is readily available to plants. However, now there are a wide variety of commercial fertilizers that contain S in an unoxidized or elemental form. These elemental S fertilizers cost less per unit of S than the sulphate-S fertilizers, but the effectiveness of these fertilizers depends on how quickly the S is oxidized in soil for effective plant uptake.

More than 4 million ha of agricultural soils are deficient in S. Substantially greater areas are potentially deficient (Bettany et al. 1982; Doyle and Cowell 1993). Canola has high requirements for S (Grant and Bailey 1993). Canola (rapeseed) grown on S-deficient Gray Wooded soils have been found to result in poor seed set (Nyborg et al. 1974; Nuttal et al. 1987). The S deficiency on canola can be eliminated by applying S fertilizers (Ukrainetz 1982; Janzen and Bettany 1984). But there are few studies on the relative effectiveness of elemental S versus sulphate-S fertilizers in increasing canola yield response to applied S on S-deficient soils (Ukrainetz 1982; Solberg 1986). Some research on the effectiveness of various sources of S on wheat and canola is being conducted in the prairies at the Brandon Research Centre (Dr. C. Grant). However, in those studies, the elemental S and sulphate-S fertilizers alone or in combinations are not applied continuously to the same plots over a number of years. Field research information is lacking on the duration for the elemental S fertilizers to become equally effective to sulphate-S fertilizers, and the number of years the combination of sulphate-S and elemental S fertilizers has to be used on canola before switching completely to elemental S fertilizers without any risk of yield loss due to S deficiency on S-deficient soils.

Objective

The objective of this study was to compare the relative effectiveness of elemental S and sulphate-S fertilizers on yield of canola seed.

Materials and Methods

The 4-year field experiments were established in 1999 on S-deficient Gray Wooded soils at two sites (Porcupine Plain with 1.8 mg SO_4-S kg^{-1} and Tisdale with 2.0 mg SO_4-S kg^{-1} in the 0-15 cm soil) in northeastern Saskatchewan. In both experiments, each treatment was replicated four times in a RCBD. Individual plots were 1.8 m x 7.5 m.

The treatments included two elemental S fertilizers (ES-90 and ES-95), a fertilizer containing both elemental S and sulphate-S (Agrium Plus) and a sulphate-S fertilizer (ammonium sulphate) plus a zero-S control. The S fertilizers were applied (at 15 kg S ha^{-1} at Porcupine Plain, and 10 and 20 kg S ha^{-1} at Tisdale) in the previous fall or in spring at sowing. The S fertilizers were surface-broadcast and all the plots were tilled in the spring before sowing. Each plot received a blanket application of 135 kg N, 50 kg P_2O_5 and 25 kg K_2O ha^{-1}. Data were recorded on seed and straw yield, and protein, oil and total S content in seed and total S in straw. The data were subjected to ANOVA and $LSD_{0.05}$ was used for mean separation.

Results and Discussion

In 1999, there was almost no canola seed yield in the absence of S application at the Porcupine Plain site (Table 1). The SO_4-S containing fertilizers (ammonium sulphate and Agrium Plus) increased the canola yield many times over the control. But Agrium Plus produced less seed yield than ammonium sulphate by 264 and 720 kg ha^{-1} with fall and spring applications, respectively. This difference was apparently due to lower effectiveness of the elemental S part of the Agrium Plus fertilizer. Two elemental S fertilizers (ES-90 and ES-95) significantly increased canola seed yield when applied in fall, but the increase was much lower than the sulphate-S containing fertilizers. Spring-applied elemental S fertilzers produced no effect on canola seed yield. Higher canola seed yield with fall than spring application of the elemental S containing fertilizers (Agrium Plus, ES-90 and ES-95) indicates that partial oxidation of elements S occurred during the canola growing season with fall but not with spring applications. On the other hand, ammonium sulphate was less effective when applied in fall than spring, probably due to some over-winter loss of S from the fertilizer.

Similar to the Porcupine Plain site, there was almost no canola seed yield in zero-S control at the Tisdale site and ammonium sulphate generally showed higher canola seed yield than Agrium Plus (Table 2). The differences between ammonium sulphate and Agrium Plus were significant with their spring applications at both S rates. But the increase in seed yield was much smaller and only spring-applied sulphate-S containing fertilizers (ammonium sulphate and Agrium Plus) at both rates and fall-applied ammonium sulphate at 20 kg S ha^{-1} increased the canola seed yield significantly above the control. Increase in canola seed yield with fall-applied sulphate-S containing fertilizers (ammonium sulphate and Agrium Plus) at both S rates was significantly lower than their spring application at the same rates. None of the elemental S only fertilizers (ES-90 and ES-95) produced significant increase in the canola seed yield above the control, although there was a tendency of increase in canola seed yield with fall application of the elemental S fertilizers.

The differences between canola seed yield with ammonium sulphate and Agrium Plus were apparently due to lower effectiveness of the elemental S part of the Agrium Plus fertilizer. Higher canola seed yield with fall than spring application of the elemental S containing fertilizers (Agrium Plus, ES-90 and ES-95) indicates that partial oxidation of elements S occurred during the canola growing season with fall but not with spring applications. On the other hand, ammonium sulphate was less effective when applied in fall than spring, probably due to some loss of S from the fertilizer. Overall, the elemental S was only partially effective when applied in fall and not effective at all with spring application and only SO_4-S part of the Agrium Plus fertilizer was effective in increasing canola seed yield.

In 2000, there was little canola seed yield in the absence of S application at the Porcupine Plain site (Table 3). The SO_4-S containing fertilizers (ammonium sulphate and Agrium Plus) increased seed yield many times over the control. Two elemental S fertilizers (ES-90 and ES-95) significantly increased seed yield when applied in fall or in spring, but the increase was much less than the sulphate-S containing fertilizers (except for the fall-applied ES-90 which produced seed yield close to sulphate-S fertilizers). Fall-applied elemental S, especially ES-90, was more effective in increasing seed yield of canola than the spring-applied elemental S. Higher seed yield with fall than spring application of the elemental S fertilizers indicates more oxidation of elements S occurring in the growing season with fall than with spring applications.

Like the Porcupine Plain site, there was little canola seed yield in zero-S control at the Tisdale site (Table 4). Both fall and spring-applied sulphate-S containing fertilizers (ammonium sulphate and Agrium Plus) at both S rates increased seed yield significantly above the control. Ammonium sulphate generally gave slightly higher seed yield than Agrium Plus. With the exception of fall-applied elemental S fertilizers at 20 kg S ha^{-1} rate which

increased seed yield close to sulphate-S fertilizers, other elemental S treatments produced much lower seed yield than the sulphate-S fertilizers. Elemental S fertilizers at both rates gave much greater seed yield when applied in fall rather than in spring. Spring-applied elemental S had the lowest seed yields.

In 2001, there was almost no canola seed yield in the absence of S application at the Porcupine Plain site (Table 5). The SO_4-S containing fertilizers (ammonium sulphate and Agrium Plus) increased seed yield many times over the control. Two elemental S fertilizers (ES-90 and ES-95) increased seed yield when applied in fall or in spring, but the increase was less than the sulphate-S containing fertilizers (except for the fall-applied ES-90 which produced seed yield close, though less, to sulphate-S fertilizers). Fall-applied elemental S, especially ES-90, was more effective in increasing seed yield of canola than the spring-applied elemental S. Higher seed yield with fall than spring application of the elemental S fertilizers indicates more oxidation of elements S occurring in the growing season with fall than with spring applications. There was almost no canola seed yield in zero-S control at the Tisdale site (Table 6). Both fall and spring-applied sulphate-S containing fertilizers (ammonium sulphate and Agrium Plus) at both S rates increased seed yield significantly above the control. With the exception of fall-applied elemental S fertilizers at 20 kg S ha^{-1} rate that increased seed yield close to sulphate-S fertilizers, other elemental S treatments produced much lower seed yield than the sulphate-S fertilizers. Elemental S fertilizers at both rates gave greater seed yield when applied in fall rather than in spring. Spring-applied elemental S had the lowest seed yields.

In 2002, canola was harvested for seed yield only at Tisdale, because at Porcupine Plain the crop did not mature prior to frost. At Tisdale, elemental S fertilizers usually corrected S deficiency on canola and increased seed yields significantly over the zero-S control, but yields were less than the sulphate-S fertilizer in many cases, especially when the S fertilizers were applied in spring (Table 7). Fall-applied elemental S usually had greater seed yield than the spring-applied elemental S, and in some cases seed yields tended to be equal to sulphate-S fertilizer. Agrium Plus usually increased seed yield similar to ammonium sulphate. Fall-applied ammonium sulphate tended to produce lower seed yield than spring-applied ammonium sulphate at the 20 kg S ha^{-1} rate.

In summary, the results suggest that the elemental S fertilizers were not as effective as the sulphate-S fertilizer in increasing canola seed yields on S-deficient soils, particularly when the S fertilizers were applied in spring at seeding.

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Table 1. Seed yield increase from various S fertilizers applied at 15 kg S/ha to canola at Porcupine Plain in northeastern Saskatchewan in 1999

	Seed yield increase (kg/ha) from applied S	
Source of S	Fall-applied	Spring-applied
ES 90	602	6
ES 95	843	11
Agrium Plus	1643	1367
Ammonium sulphate	1907	2087

Table 2. Seed yield increase from various S fertilizers applied at two rates to canola near Tisdale in northeastern Saskatchewan in 1999

	Rate of S	Seed yield increase (kg/ha) from applied S	
Source of S	(kg S/ha)	Fall-applied	Spring-applied
ES 90	10	0	0
	20	22	0
ES 95	10	22	0
	20	80	0
Agrium Plus	10	64	54
	20	241	473
Ammonium sulphate	10	83	346
	20	272	828

Table 3. Seed yield increase from various S fertilizers applied at 15 kg S/ha to canola at Porcupine Plain in northeastern Saskatchewan in 2000

	Seed yield increase (kg/ha) from applied S	
Source of S	Fall-applied	Spring-applied
ES 90	1432	704
ES 95	892	655
Agrium Plus	1508	1612
Ammonium sulphate	1645	1703

Table 4. Seed yield increase from various S fertilizers applied at two rates to canola near Tisdale in northeastern Saskatchewan in 2000

	Rate of S	Seed yield increase (kg/ha) from applied S	
Source of S	(kg S/ha)	Fall-applied	Spring-applied
ES 90	10	284	31
	20	572	94
ES 95	10	233	44
	20	612	156
Agrium Plus	10	542	615
	20	885	760
Ammonium sulphate	10	667	747
	20	728	919

Table 5. Seed yield increase from various S fertilizers applied at 15 kg S/ha to canola at Porcupine Plain in northeastern Saskatchewan in 2001

	Seed yield increase (kg/ha) from applied S	
Source of S	Fall-applied	Spring-applied
ES 90	498	204
ES 95	204	85
Agrium Plus	677	561
Ammonium sulphate	675	803

Table 6. Seed yield increase from various S fertilizers applied at two rates to canola near Tisdale in northeastern Saskatchewan in 2001

	Rate of S	Seed yield increase (kg/ha) from applied S	
Source of S	(kg S/ha)	Fall-applied	Spring-applied
ES 90	10	65	105
	20	349	195
ES 95	10	159	56
	20	275	109
Agrium Plus	10	292	344
	20	405	419
Ammonium sulphate	10	394	346
	20	368	399

Table 7. Seed yield increase from various S fertilizers applied at two rates to canola near Tisdale in northeastern Saskatchewan in 2002

	Rate of S	Seed yield increase (kg/ha) from applied S	
Source of S	(kg S/ha)	Fall-applied	Spring-applied
ES 90	10	470	148
	20	490	268
ES 95	10	199	90
	20	472	212
Agrium Plus	10	555	500
	20	681	630
Ammonium sulphate	10	543	557
	20	682	812

-ES 90 and ES 95 are elemental S fertilizers and Agrium Plus contains both elemental S.